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▶ **To cite this version:**

Joris Ravaglia, Alexandra Bac, Richard A Fournier. Spatial vegetation density index from terrestrial laser scanner. IEEE Geoscience and Remote Sensing Society (IGARSS), Jul 2014, Québec, Canada. hal-01376468

HAL Id: hal-01376468
https://hal.science/hal-01376468

Submitted on 4 Oct 2016

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Spatial Vegetation Density Index From Terrestrial Laser Scanner

J. Ravaglia[1,2], A. Bac[1] and R. Fournier[2]
[1] Université de Sherbrooke, Sherbrooke, Canada
[2] Université d'Aix-Marseille, Marseille, France

Background and Objectives

Introduction: Forest monitoring is a key issue in scientific, social and commercial domains. Manual measurements of forests attributes can be tedious and limited. Terrestrial Laser Scanner (TLS) has been introduced in forest monitoring [1]. Vegetation density index is a way to quantify vegetation using **voxels** from TLS data [2].

Problem statement: The vegetation density index is estimated using ray tracing techniques in a 3D voxel grid. This process can be time consuming and can be improved.

Objectives:
- Decrease the computing time
- Increase the consistency of the calculus

Figure 1: TLS point cloud and voxelisation of a tree

Methodology

1. Identify the visible faces of all voxels
2. Compute their solid angles (eq. 1)
3. Compute the adjustment factor (eq. 4)
4. Compute the density index (eq. 5)

Density Index

Assumption: The number of laser beams intercepted within a volume is proportional to the density of vegetation.

Density index: this index is defined as :

$$D = \frac{N_i}{N_t - N_b} 100$$

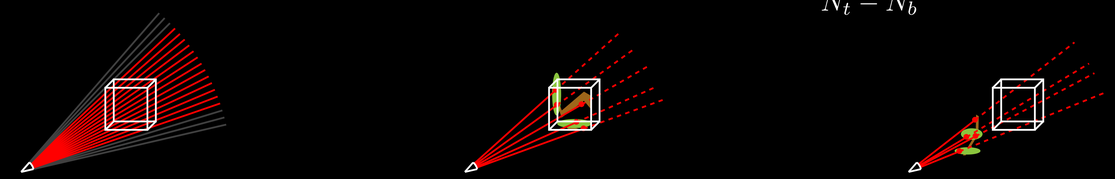

Figure 2: Density index computation using raytracing [3]

Analytic Approach

Analytic calculus of theoretical number of beams N_t for each voxel :

$$\Omega = \sum \Omega_i \quad (1)$$

$$dS = \rho^2 \cdot \sin\phi \cdot d\phi d\theta \quad (2)$$

$$\Delta S = \int_{\theta}^{\theta+\Delta\theta} \int_{\phi}^{\phi+\Delta\phi} dS \quad (3)$$

$$\overline{\Delta S} = \frac{1}{\phi_2 - \phi_1} \frac{1}{\theta_2 - \theta_1} \int_{\theta_1}^{\theta_2} \int_{\phi_1}^{\phi_2} \Delta S d\phi d\theta \quad (4)$$

$$N_t = \frac{\Omega}{\Delta S} \quad (5)$$

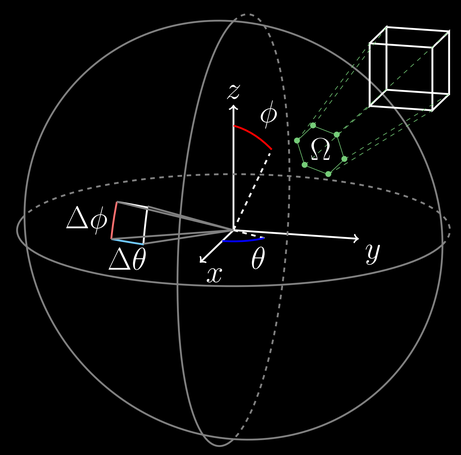

Figure 5: Spherical geometry for the analytic calculus

Results

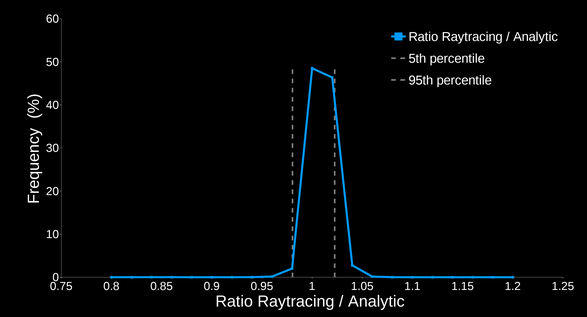

Figure 3: Comparison of density index between raytracing technique and analytical solution

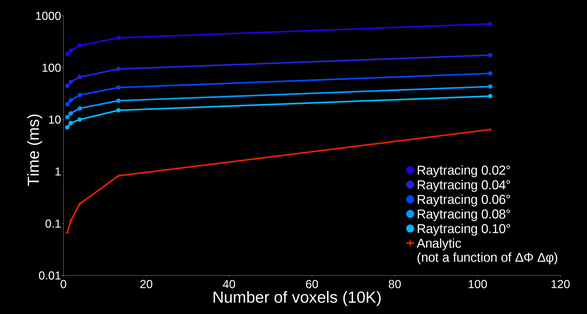

Figure 4: Computational time for both approaches

Conclusion

- Raytracing and analytic process give **similar results**
- The analytical calculus represents an important **gain of time**
- **Parallel processing** is easy to set up

Future Research

Characterizing the **limits** and **conditions** that need to be fulfilled while using our methodology.

Provide an **analytical calculus** for the average distance covered by a beam inside a voxel.

Contact Information

Web www.cartel.recherche.usherbrooke.ca
Email joris.ravaglia@usherbrooke.ca
Phone +1 (819) 821 8000 - extension 62945

ULiUS
Unité LiDAR de l'Université de Sherbrooke
Département de géomatique appliquée

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